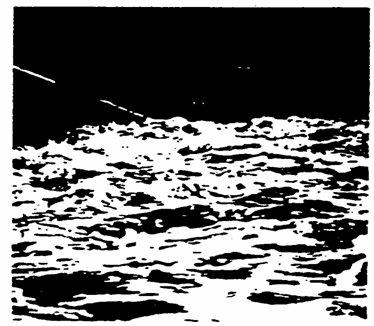
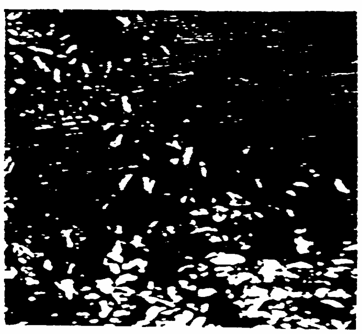
APPENDIX J

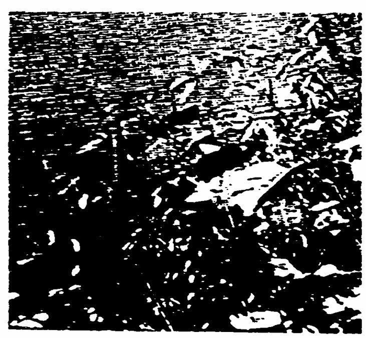
Description of Filter and Drainage Diaphragm for Seepage Control (Source: NRCS)

TR60

Earth Dams and Reservoirs







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210-VI

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Soil Conservation Service
Engineering Division

Only joints incorporating a round rubber gasket set in a positive groove which will prevent its displacement from either internal or external pressure under the required joint extensibility are to be used on precast concrete pipe conduits. Concrete pipe must have steel joint rings providing rubber to steel contact in the joint.

Articulation of the conduit (freedom for required rotation) is to be provided at each joint in the conduit, at the junction of the conduit with the riser and any outlet structure. Concrete bedding for pipe conduits need not be articulated. Cradles are to be articulated if on yielding foundations. Welded steel pipe conduits need not be articulated if the pipe and bedding rest directly on firm bedrock.

Piping and Seepage Control - Use a filter and drainage diaphragm around any structure that extends through the embankment to the downstream slope. Design the diaphragm with single or multizones to meet the requirements of Soil Mechanics Note No. 1.

Locate the diaphragm aligned approximately parallel to the centerline of the dam or approximately perpendicular to the direction of seepage flow. Extend the diaphragm horizontally and vertically into the adjacent embankment and foundation to intercept potential cracks, poorly compacted soil zones or other discontinuities associated with the structure or its installation.

Design the diaphragms to extend the following minimum distances from the surface of rigid conduits:

1. Horizontally and vertically upward 3 times the outside diameter of circular conduits or the vertical dimension of rectangular box conduits except that:

    a. the vertical extension need be no higher than the maximum potential reservoir water level, and

    b. the horizontal extension need be no further than 5 feet beyond the sides and slopes of any excavation made to install the conduit.

2. Vertically downward:

    a. for conduit settlement ratios (δ) of 0.7 and greater (reference SCS Technical Release No. 5), the greater of (1) 2 feet or (2) 1 foot beyond the bottom of the trench excavation made to install the conduit. Terminate the diaphragm at the surface of bedrock when it occurs within this distance. Additional control of general seepage through an upper zone of weathered bedrock may be needed.

    b. 1.5 times the outside diameter of circular conduits or the outside vertical dimension of box conduits for conduit settlement ratios (δ) less than 0.7.

(210-VI-TR60, Revised, Amend. 1, Oct. 1990)

Design the diaphragms to extend in all directions a minimum of 2 times the outside diameter from the surface of flexible conduits, except that the diaphragm need not extend beyond the limits in 1a and 1b above nor beyond a bedrock surface beneath the conduit.

Provide minimum diaphragm thickness of 3 feet and minimum thickness of 1 foot for any zone of a multizone system. Use larger thickness when needed for (1) capacity, (2) tieing into embankment or foundation drainage systems, (3) accommodating construction methods, or (4) other reasons.

For homogeneous dams, locate the diaphragm in the downstream section of the dam such that it is:

1. Downstream of the cutoff trench,
2. Downstream of the centerline of the dam when no cutoff trench is used, and
3. Upstream of a point where the embankment cover (upstream face of the diaphragm to the downstream face of the dam) is at least one-half of the difference in elevation between the top of the diaphragm and the maximum potential reservoir water level.

For zoned embankments, locate the diaphragm downstream of the core zone and/or cutoff trench, maintaining the minimum cover as indicated for homogeneous dams. When the downstream shell is more pervious than the diaphragm material, locate the diaphragm at the downstream face of the core zone.

It is good practice to tie these diaphragms into the other drainage systems in the embankment or foundation. Foundation trench drains and/or embankment chimney drains that meet the minimum size and location limits are sufficient and no separate diaphragm is needed.

Design the minimum capacity of outlets for diaphragms not connected to other drains by assuming the coefficient of permeability (k) in the zone upstream of the diaphragm is 100 times the coefficient of permeability in the compacted embankment material. Assume this zone has a cross-sectional area equal to the diaphragm area and the seepage path distance equal to that from the embankment upstream toe to the diaphragm. This higher permeability simulates a sealed filter face at the diaphragm with partially filled cracks and openings in the upstream zone.

For channels, chutes or other open structures, seepage and piping control can be accomplished in conjunction with drainage for reduction of uplift and water loads. The drain, properly designed to filter the base soils, is to intercept areas of potential cracking caused by shrinkage, differential settlement or heave and frost action. These structures usually require the use of footings, keywalls and counterforts and drainage is properly located immediately downstream of these features. This drainage when properly designed can control piping and provide significant economies due to the effect on soil loads, uplift pressures, overturning forces and sliding stability.

Outlets

The choice of outlet is to be based on a careful consideration of all site and flow conditions that may affect operation and energy dissipation.

1. Cantilever outlet and plunge pools may be installed where their use:

   a. Does not create a piping hazard in the foundation of the structure.

   b. Is compatible with other conditions at the site.

   Plunge pools are to be designed to dissipate the energy and be stable. Unless the pool is to be in bedrock or very erosion resistant materials, riprap will be necessary to insure stability. Design Note 6, entitled, "Armored Scour Hole for Cantilever Outlet", is to be used for design.

   Cantilever outlets are to be supported on bents or piers and are to extend a minimum of 8 feet beyond the bents or piers. The bents are to be located downstream from the intersection of the downstream slope of the earth embankment with the grade line of the channel below the dam. They are to extend below the lowest elevation anticipated in the plunge pool. The invert of the cantilever outlet is to be at least 1 foot about the tailwater elevation at maximum discharge.

2. SAF basins may be used when there is adequate control of tailwater. Use TR-54 for structural design and NEH-14 for hydraulic design.

3. Impact basins may be used when positive measures are taken to prevent large debris from entering the conduit. TR-49 is to be used for hydraulic design.

Trash Racks

Trash racks are to be designed to provide positive protection against clogging of the spillway under any operating level. The average velocity of flow through a clean trash rack is not to exceed 2.5 feet per second under the full range of stage and discharge. Velocity is to be computed on the basis of the net area of opening through the rack.

If a reservoir outlet with a trash rack or a ported concrete riser is used to keep the sediment pool drained the trash rack or riser is to extend above the anticipated sediment elevation at the riser to provide